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Research Article

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Production of Cotton Stalk Charcoal / Biomass Briquettes for Use in low income House Holds

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Abstract Millet chaff, Rice husk, and Cotton stalk are large portion of Biomass produced in all agricultural practicing areas of the world. These wastes were investigated as source of solid fuel, fifteen sets of solid fuel briquettes were produced using cassava starch as a binder. Following current briquetting technology was carried out using locally fabricated briquetting machine. Burning potential tests were carried out on the formed briquettes compared to that of firewood. It showed that fire wood boils five litres of water in sixty minutes, while millet chaff from Biu (A2), both millet chaff of Zabarmari (C2) and rice husk of Nganzai (B3), millet chaff of Nganzai (B2) and rice husk of Biu (A3), cotton stalk charcoal of Nganzai (B1) and millet chaff of Zabarmari (C3), cotton stalk charcoal of Zabarmari (C1) and rice husk blend of Nganzai (B5), cotton stalk charcoal of Biu (A1), and millet chaff blend of Biu (A4),millet chaff blend of Nganzai (B4), and millet chaff blend of Zabarmari (C4), while rice husk blend of Biu (A5), and rice husk blend of Zabarmari (C5) boils the same volume of water in fifty, fourty five, fourty, thirty five, twenty five, and twenty minutes respectively. These results show that there is superiority of produced briquettes over firewood in terms of burning characteristics.

Keywords Millet chaff, Rice husk, Cotton stalk charcoal, Briquettes, Cassava starch

Introduction

Human activities especially in the household requires a lot of energy; the most common sources of energy utilized for cooking in Nigeria have been a product of fossil fuels such as kerosene and natural gas [8]. A survey of both rural and urban areas of Nigeria showed that 80% of households depend on fuel wood, and charcoal for cooking and heating rooms [6]. In some homes, electricity is also used even though, pollution free, the supply is erratic and unreliable, our fossil fuel reserves are depleting as both the population and per capita use of the energy is expanding rapidly [1]. However, it appears that coal will be the backbone of our energy system long after the reserves of petroleum and natural gas are depleted, but the use and handling of it has serious problems [4], the use of wood and charcoal fuels is an important cause of deforestation and causes global warming due to greenhouse effect, one of the most urgent environmental problems in Africa [20].
Other sources of energy include sunlight, geothermal power, wind and tidal movements, but none of these are economical now for large-scale uses, and cannot be affordable especially for the rural and semi urban dwellers [10]. Agro waste is the most promising energy resource for developing countries like ours [2]. The decreasing availability of woods, and charcoal fuels has necessitated that efforts be made towards efficient utilization of agricultural wastes, these wastes have acquired considerably importance as fuels for many purposes, for instance, domestic cooking and industrial heating [9]. Some of these agricultural wastes for example, rice husk,

saw dust, millet straw, guinea corn straw, groundnut shell, coconut shell, wood pulp, and wood waste etc can be utilized directly as fuels [7].

Therefore, the need to search for renewable alternative sources of energy especially for cooking and other domestic uses for rural dwellers is necessary [21]. Even in the developed countries which have relevant skills, organization and financial resources, efforts are being made towards the development of alternative renewable sources of energy; even though it could be as a result of improvement in the standard of living with increased in per capita consumption of energy [11]. Although there are many problems with plentiful supply of energy of all sort, these energies indeed, cannot be pollution free [17].

Biomass, particularly agricultural wastes seem to be one of the most promising energy resources for developing countries [15]. Rural households and minority of urban dwellers depend solely on (charcoal, firewood, straws of corn, maize and millet) fuels as their primary sources of energy for the past decades [14]. Of all the available energy resources in Nigeria, coal and coal derivatives such as smokeless coal briquettes, bio-coal briquettes, and biomass briquettes have been shown to have the highest potential for use as suitable alternative to coal/ fuel wood in industrial boiler and brick kiln for thermal application and domestic purposes [12]. Global warming has become an international concern. Global warming is caused by greenhouse gasses which carbon dioxide is among the major contributors [18]. It was shown that increased emissions of CO_2 have been drastically reduced owing to the fact that the rate of deforestation is higher than the afforestation effort in the country [17].

Briquetting biomass waste has many notable benefits, many of which minimize the impact of the waste generated by indiscriminate dumping system [21]. This also reduces landfills through the process of using waste materials found in dump sites and on farms across the agricultural practice areas, and even on the processing point causes soil and water pollution [19]. In addition to the cost saving associated with reducing the volume of waste, briquetting is more useful for cleaning the environment; nevertheless, briquetting process provides an alternative fuel, and can help slow the process of deforestation [16].

On the other hand, the majority of the huge materials are not suitable to be used directly as fuel without undergoing some processes [1]. This is probably as a result of inappropriate density and high moisture contents and these factors may cause problems in transportation, handling and storage [13]. Most of these wastes are left to decompose or when they are burnt, there would be environmental pollution and degradation [5]. Researchers have shown that lots of potential energies are abounding in these residues. Hence, there is a need to convert these wastes into forms that can alleviate the problems they pose when use directly [3].

Material and Method

Raw Materials

The raw materials used include: Millet chaffs, Rice husks, Cotton stalk charcoals, and Cassava starch.

Apparatus/instruments

Triple beam balance, model: MB-2610g, Locally fabricated briquetting machine and mould, Laboratory thermometer, Stop watch/clock, Mortar and pestle, Plastic basins, Aluminum kettle (2litres),Measuring cylinder(1000ml), Analytical balance sensitive to 0.1mg, Siever,), Aluminum pots, Locally fabricated stoves,

Chemicals/reagents

Calcium hydroxide, Distilled water.

Methods

Preparation of Samples

The cotton stalks biomass were carbonized using the conventional earth kiln method as traditionally used for wood carbonization. The fully carbonized material was collected, air dried for 2 days, after which they were pulverized. Millet chaffs, and rice husks were sorted and as well pulverized into fine powder and sieved using 1mm siever. The briquettes were produced using cassava starch paste as a binder, fifteen sets of briquettes were produced at a ratio of 4:2 (Agricultural wastes: cassava starch paste wt/wt). The various mixtures were loaded into cylindrical mould and compressed for some time, the compressed briquettes were later extruded and sun dried for a week, sample briquettes shown on plate 1

Plate 1: Sample Briquettes

Water boiling test

The water boiling test is a measures of time taken for a given quantity of fuel to heat and boil a given quantity of water. 5kg of each quantity of both briquettes and firewood was measured. The first briquette sample was stacked in a local fabricated stove while the firewood was stacked in a different stove. The stoves were ignited and as soon as the flames were stabilized for 5 minutes, two aluminum pots containing 5 litres of water each were mounted on the stoves. A stopwatch was activated. The initial temperatures of the water were noted and thereafter readings were obtained at 5 minutes interval using a thermometer. This was terminated after attaining boiling point. Similarly a known quantity of the second sample was stacked in the stove while firewood was stacked in the second stove and the procedure repeated for the other briquette samples. All these procedure was done for cotton stalk charcoals (A1, B1, C3), millet chaffs (A2, B2,C2),rice husks (A3, B3, C3), cotton stalks charcoal blended with millet chaffs (A4, B4, C4), cotton stalk charcoals blended with rice husks (A5, B5, C5), all against firewood as shown on plate 2.

Plate 2: Water Boiling Experiments

Results and Discussion

The result obtained from the water boiling test for all produced briquettes are show on tables 1 to 5

Table 1: Water Boiling Test of Cotton Stalk Charcoals against Firewood

S/N	Time (s)	A1	B1	C1	firewood
		Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)
1.	0	31	31	31	31
2.	5	60	50	55	45
3.	10	0	58	65	50
4.	15	80	66	75	55
5.	20	90	4	85	60
6.	25	100	82	95	65
7.	30	-	90	100	70
8.	35	-	100	-	75
9.	40	-	-	-	80
10.	45	-	-	-	85
11.	50	-	-	-	90
12.	55	-		-	95
13.	60	-	-	-	100

Table 2: Water Boiling Test of Millet Chaffs against Firewood

S/N	Time (s)	A2	B2	C2	Firewood
		Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)
1.	0	31	31	31	31
2.	5	46	48	47	45
3.	10	52	56	54	50
4.	15	58	72	61	55
5.	20	64	78	68	60
6.	25	70	84	75	65
7.	30	76	90	82	70
8.	35	82	96	89	75
9.	40	88	100	96	80
10.	45	94	-	100	85
11.	50	100	-	-	90
12.	55	-	-	-	95
13.	60	-	-	-	100

Table 3: Water Boiling Test of Rice Husk against Firewood

S/N	Time (s)	A3	B3	C3	Firewood
		Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)
1.	0	31	31	31	31
2.	5	48	47	49	45
3.	10	56	54	58	50
4.	15	72	61	67	55
5.	20	78	68	76	60
6.	25	84	75	85	65
7.	30	90	82	94	70
8.	35	96	89	100	75
9.	40	100	96	-	80
10.	45	-	100	-	85
11.	50	-	-	-	90
12.	55	-	-	-	95
13.	60	-	-	-	100

Table 4: Cotton Stalk Charcoal blend with Millet Chaffs against Firewood

S/N	Time (s)	A4	B4	C4	Firewood
		Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)
1.	0	31	31	31	35
2.	5	65	65	65	45
3.	10	75	75	75	50
4.	15	85	85	85	55
5.	20	95	95	95	60
6.	25	100	100	100	65
7.	30	-	-	-	70
8.	35	-	-	-	75
9.	40	-	-	-	80
10.	45	-	-	-	85
11.	50	-	-	-	90
12.	55	-	-	-	95
13.	60	-	-	-	100

Table 5: Cotton Stalk Charcoal blend with Rice Husk against Firewood

S/N	Time (s)	A5	B5	C5	Firewood
		Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)	Temp (^{O}C)
1.	0	31	31	31	31
2.	5	78	56	78	45
3.	10	88	66	88	50
4.	15	98	76	98	55
5.	20	100	86	100	60
6.	25	-	96	-	65
7.	30	-	100	-	70
8.	35	-	-	-	75
9.	40	-	-	-	80
10.	45	-	-	-	85
11.	50	-	-	-	90
12.	55	-	-	-	95
13.	60	-	-	-	100

Results and Discussion

Table 1 shows the variation of temperature with time for both cotton stalk charcoal briquettes and firewood. It is seen from this table that the cotton stalks charcoal briquettes (A1, B1, and C1) attained a temperature of 100 ^{0}C in 25, 40, and 30 minutes while fire wood attained 100^{0}C at 60 minute. In 0 minutes the samples and firewood all start a temperatures of 31 minutes. This indicates that A1 shows a better combustion characteristics followed by C1, then B1 compared to firewood. This clear difference can be observed from the graph of temperature versus time for all the cotton stalk charcoal briquettes (A1, B1, and C1) and firewood as shown in figure 1.

Similarly, table 2 shows the variation of temperature with time for all the millet chaffs - cassava starch briquette and fire wood both from initial temperature of 31^{0}C, it is seen from this table the millet chaffs starch briquette (A2,B2, and C2) attained a temperature of 100^{0}C in 50,40, and 45 minutes while fire wood attained a temperature of 100^{0}C at a time of 60 minutes This difference can also be observed from the graph of temperature versus time for all the millet chaffs – starch briquettes and firewood as shown in figure 2. Also, table 3 shows the variation of temperature with time for all the Rice husks - cassava starch briquette (A3, B3, and C3) and fire wood both from initial temperature of 31^{0}C, it is seen from this table that the rice husk starch briquette (A3, B3, and C3) attained a temperature of 100^{0}C in 40, 45 and 35 minutes respectively while fire wood attained same temperature of 100^{0}C at a time of 60 minutes This difference can also be observed from the graph of temperature versus time for all the rice husk – starch briquettes and firewood as shown in figure 3.

Table 4 shows the variation of temperature with time for both cotton stalk charcoal blended briquettes with millet chaffs-starch and firewood. It is seen from this table that the cotton stalks charcoal blended with millet chaffs briquettes (A4, B4, and C4) attained a temperature of 100 ^{0}C in 25 minutes each, while fire wood attained that same 100^{0}C at 60 minute. This clear difference can be observed from the graph of temperature versus time for all the cotton stalk charcoal briquettes blended with millet chaffs and firewood as shown in figure 4.

Table 5 shows the variation of temperature with time for both cotton stalk charcoal blended briquettes with rice husk-starch and firewood. It is seen from this table that the cotton stalks charcoal blended with rice husk briquettes (A5, B5, and C5) attained a temperature of 100 ^{0}C in 20,30, and 20 minutes respectively, while fire wood attained that same 100^{0}C temperature in 60 minute. This clear difference can be observed from the graph of temperature versus time for all the cotton stalk charcoal briquettes blended with rice husk and firewood as shown in figure 5.

The rapid combustion observed in the briquettes samples may be due to porous nature of the briquettes compared to the relatively dense nature of the firewood. The porosity in the briquettes enables the volatile matters to leave more readily and be consumed rapidly in the flame. This explains the sharp temperature rise within the first 5 minutes and the fact that cellulose materials often display flaming combustion [21]. This indicates that all the briquettes – starch combust more efficiently than firewood.

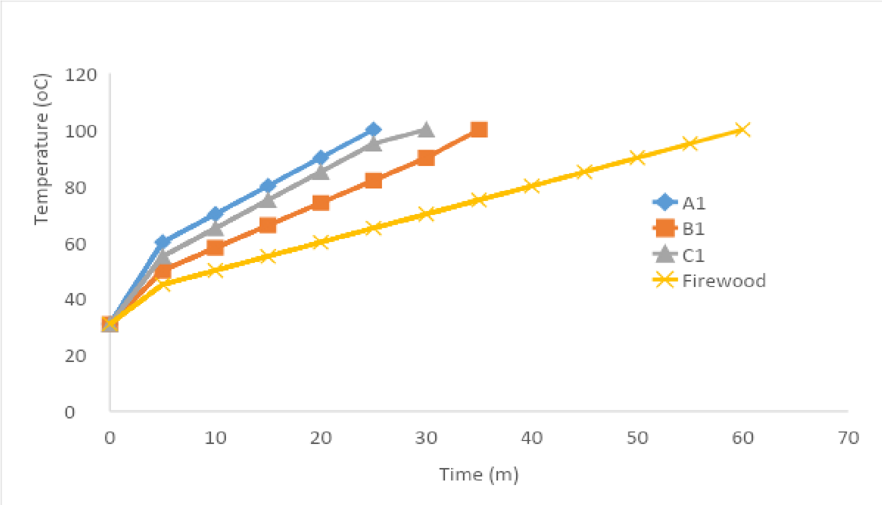

Figure 1: Burning Efficiency of Cotton Stalk Charcoals against. Firewood

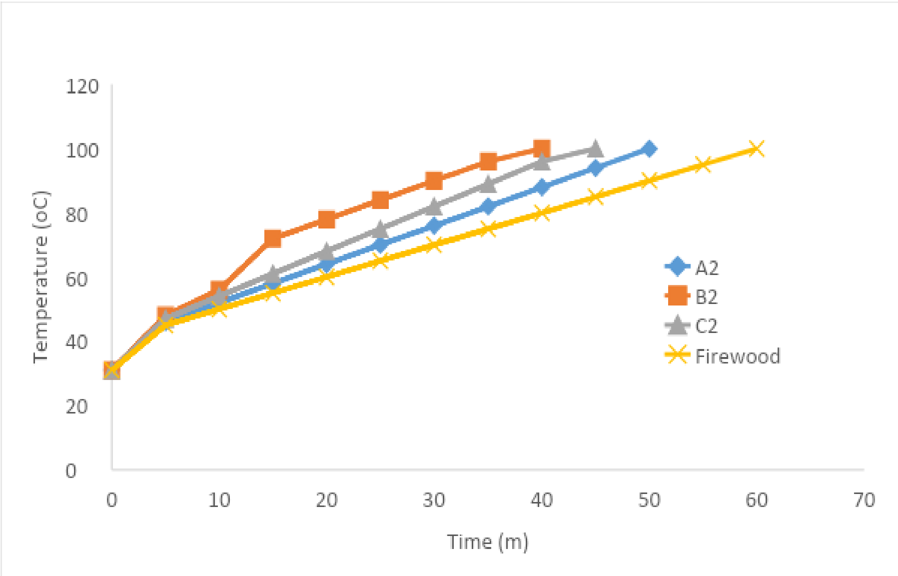

Figure 2: Burning Efficiency of Millet Chaffs against Firewood

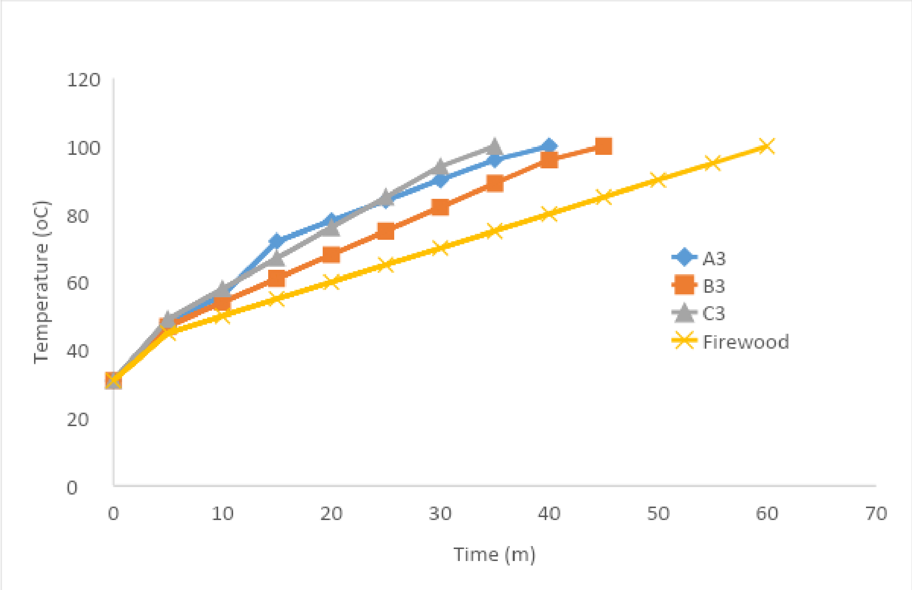

Figure 3: Burning Efficiency of Rice Husks against Firewood

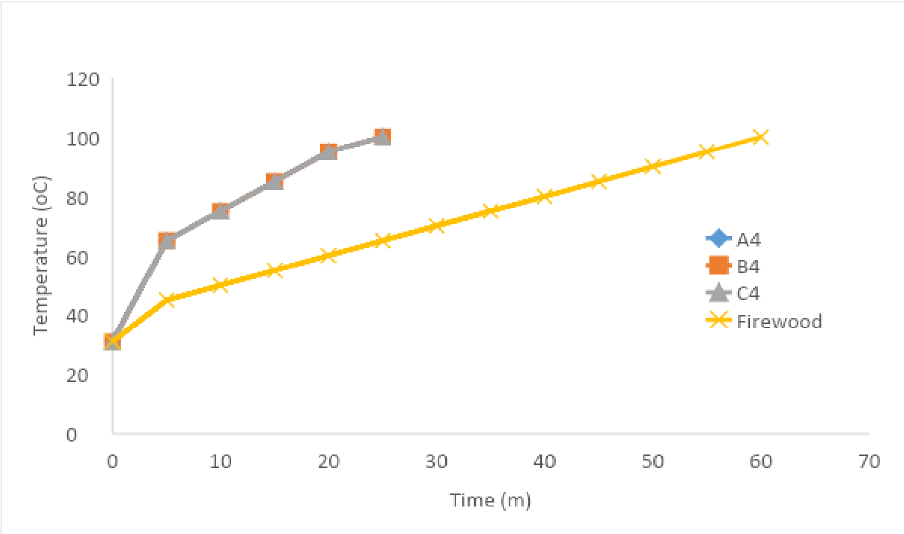

Figure 4: Burning Efficiency Cotton Stalk Charcoals Blended with Millet Chaffs against Firewood

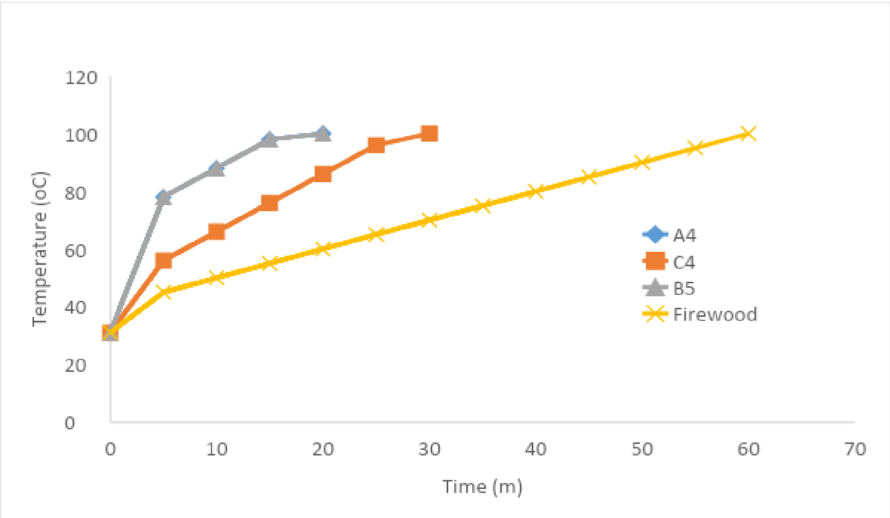

Figure 5: Burning Efficiency Cotton Stalk Charcoals Blended with Rice Husks against Firewood

Conclusion

Fifteen briquettes grades were produced, and their combustive properties determined. It was concluded that the conversion of agricultural waste biomass resources into briquettes is an effective means of managing this solid wastes. Furthermore, due to the abundance of wastes their conservation into solid fuel does not only provide fuel but also keep the environment clean, helps to check deforestation by felling of trees for fuel wood. The briquettes will serve as substitute for fuel wood since it shows superior combustion characteristics over fuel wood and the material is readily available. The briquetting process is economically, cheap and affordable to the rural and low-income households. Besides, the binders used do not contain harmful agents. Briquetting technology has the potential to provide employment to the teaming restive youth in northern Nigeria.

The use briquettes by the target families, not only for the cost savings involved but also for the higher performance, ease of use and health care issues. Communication and awareness workshops will play a very important awareness role in using briquettes as substitute for traditional fuel materials. The concerned authorities may consider in the future to facilitate the production and consumption of solid fuel briquettes.

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